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(54) Title: UNSUPERVISED ADAPTIVE CHIP SEPARATION FILTER FOR CDMA TERMINAL
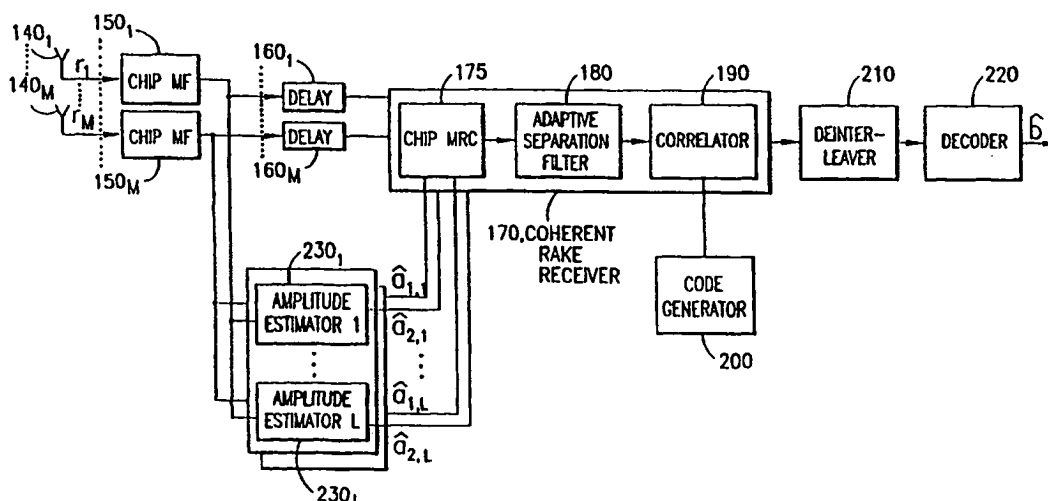
(57) Abstract

A receiver for use in a CDMA telecommunications system is disclosed. The receiver includes at least one antenna for receiving signals from a CDMA channel, where the received signals include a desired user signal. The receiver also includes combining circuitry, for performing chip waveform filtering and maximal ratio combining, to produce mutually correlated chip estimates of the received signals. The receiver further includes an adaptive separator, for adaptively separating the mutually correlated chip estimates, and a correlator, for despreading the output of the adaptive separator to obtain an estimate for data symbols of the desired user signal. In addition, the receiver further includes estimating circuitry, coupled to the combining circuitry, for estimating a response of the channel, where the combining circuitry utilizes the channel response estimate as a reference.

UNSUPERVISED ADAPTIVE CHIP SEPARATION FILTER FOR CDMA TERMINAL

This is a continuation in part of U.S. Patent Application 09/_____, entitled
5   "Unsupervised Adaptive Chip Separation Filter for CDMA Terminal" by Petri
Komulainen and Markku J. Heikkilä, Attorney Docket 872.8547 USU, filed March
3, 2000, Express Mail No.:EL 470231259US, which claims priority under 35 U.S.C.
§119(e) from Provisional Patent Application 60/123,603, filed March 10, 1999, entitled
"Unsupervised Adaptive Separation Filter" by Petri Komulainen and Markku J.
10   Heikkilä. The disclosure of this Provisional Patent Application is incorporated by
reference herein in its entirety.

FIELD OF THE INVENTION:

This invention relates generally to communications systems, and, in particular to a
receiver that performs adaptive channel equalization.

15   ## BACKGROUND OF THE INVENTION:

CDMA systems are based on a digital, wideband, spread spectrum technology
which transmits multiple, independent user signals across an allocated segment of
the radio spectrum. In CDMA, each user signal includes a different orthogonal code
and a pseudo random binary sequence that modulates a carrier, spreading the
20   spectrum of the waveform, and thus allowing a large number of user signals to share
the same frequency spectrum. The user signals are separated in the receiver with a
correlator which allows only the signal with the selected orthogonal code to be
despread. The other user signals, whose codes do not match, are not despread, and
as such, contribute to system noise. The signal to noise ratio of the system is
25   determined by the ratio of the desired signal power to the sum of all interfering
signals, enhanced by the system processing gain and the ratio of the spread
bandwidth to the baseband data rate.

In the downlink (base station to mobile terminal) of a cellular direct-sequence code
division multiple access (DS-CDMA) system, various users are multiplexed to the
30   channel typically by orthogonal spreading codes. This is also the case with the 3rd
generation wideband CDMA (WCDMA) standards currently proposed, where
different spreading factors and variable user data rates can be supported

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fading, the orthogonality between the various users' waveforms is degraded, and multiple access interference impairs the performance of the receiver. For an uplink (mobile terminal to base station) receiver, several multiuser detection schemes have been proposed in order to alleviate multiple access interference. However, the

5   mobile terminal cannot accommodate the same degree of computational complexity as the base station.

Several adaptive algorithms, based on stochastic gradient methods and minimum mean-squared-error (MMSE) criterion, have been proposed as a means of low-complexity interference suppression for CDMA receivers. In the presence of known

10   training data sequences, a least-mean-square (LMS) algorithm can be used.

Reference in this regard may be had to S. L. Miller , "An Adaptive Direct-Sequence Code-Division Multiple Access Receiver for Multiuser Interference Rejection," *IEEE Transactions on Communications*, vol. 43, pp. 1746-1755, Feb.-Apr. 1995.

Adequate training for the LMS can also be provided by a conventional RAKE

15   receiver, as is disclosed in M. Latva-aho, *Advanced receivers for wideband CDMA systems*. Doctoral thesis, Department of Electrical Engineering, University of Oulu, Finland, 1998.

In order to avoid the need for training, blind adaptation schemes have been proposed as described in: M. L. Honig, U. Madhow and S. Verdú, "Blind adaptive

20   multiuser detection," *IEEE Transactions on Information Theory*, vol. 41, pp. 944-960, July 1995, and also described in: N. Zecevic and J. H. Reed, "Blind adaptation algorithms for direct-sequence spread-spectrum CDMA single-user detection," *IEEE International Vehicular Technology Conference*, VTC'97, May 1997, pp. 2133-2137.

25   Y. Bar-Ness and J. B. Punt, "Adaptive bootstrap CDMA multi-user detector," *Wireless Personal Communications*, Kluwer Academic Publishers, vol. 3, no. 1, pp. 55-71, 1996, and P. Komulainen, Y. Bar-Ness and J. Lilleberg, "Simplified bootstrap adaptive decorrelator for CDMA downlink," *IEEE International Conference on Communications*, ICC'98, Atlanta, USA, June 1998, pp. 380-384

30   both disclose algorithms based on blind signal separation, and these algorithms are shown to have equal performance with a linear MMSE receiver. It should be noted however, that in multipath channels, the blind adaptation schemes need some form of channel response estimation. For channel estimation, either a common pilot

The formerly proposed adaptive approaches focus on the detection of the data symbols, thus requiring the signal to be cyclostationary at the symbol level. Unfortunately, this excludes their application to systems employing long pseudonoise (PN) scrambling codes, which change the correlation properties of the signal from one symbol interval to another.

In most digital radio communication systems, intersymbol interference (ISI) is introduced due to multipath propagation in the channel. This problem is significant especially at high data rates, and it may be alleviated by channel equalization.

Reference in this regard may be had to D. P. Taylor, G. M. Vitetta, B. D. Hart and A. Mämmelä, "Wireless channel equalisation," *European Transactions on Tele-communications*, vol. 9, no. 2, pp. 117-143, 1998.

In the CDMA downlink, multiple access interference is essentially caused by the channel, since all the users' signals propagate through the same frequency-selective multipath channel to the receiver of interest. Therefore, the orthogonality between the users can be restored and interference may be suppressed by compensating for the channel effects as disclosed in: S. Werner and J. Lilleberg, "Downlink channel decorrelation in CDMA systems with long codes, "*IEEE International Vehicular Technology Conference*, VTC'99, Houston, Texas, May 1999.

OBJECTS AND ADVANTAGES OF THE INVENTION:

It is an object and advantage of this invention to provide an improved receiver which utilizes an adaptive channel equalization function to restore the orthogonality between different users' waveforms.

It is a further object and advantage of this invention to utilize an adaptive channel equalization function in the receiver which operates to perform linear interchip interference chip cancellation by adaptive chip separation, by decorrelating consecutive transmitted chips.

It is a further object and advantage of this invention to provide a receiver with improved performance which is suited for systems using long scrambling codes such as third generation WCDMA systems.

SUMMARY OF THE INVENTION:

The foregoing and other problems are overcome and the objects of the invention are realized by methods and apparatus in accordance with embodiments of this invention.

5   A receiver for use in a CDMA telecommunications system is disclosed. The receiver includes at least one antenna for receiving signals from a CDMA channel, where the received signals include a desired user signal. The receiver also includes combining circuitry, for performing chip waveform filtering and maximal ratio combining, to produce mutually correlated chip estimates of the received signals. The receiver
10   further includes an adaptive separator, for adaptively separating the mutually correlated chip estimates, and a correlator, for despreading the output of the adaptive separator to obtain an estimate for data symbols of the desired user signal.

In addition, the receiver further includes estimating circuitry, coupled to the combining circuitry, for estimating a response of the channel, where the combining
15   circuitry utilizes the channel response estimate as a reference.

BRIEF DESCRIPTION OF THE DRAWINGS:

The above set forth and other features of the invention are made more apparent in the ensuing Detailed Description of the Invention when read in conjunction with the attached Drawings, wherein:

20   Figure 1 shows a block diagram of a CDMA base station transmitter.

Figure 2 shows a block diagram of a receiver in accordance with an aspect of this invention.

Figure 3 shows a block diagram of the structure of an adaptive separation filter in accordance with the teachings of this invention.

25   Figure 4 shows the bit error rate (BER) performance curves of the receiver using a spreading factor $N=32$ and a single receiver antenna.

Figure 5 shows the BER performance curves using a spreading factor $N=32$ and a two antenna receiver.

Figure 6 shows the BER performance curves when using a spreading factor $N=4$ and

Figure 7 shows the BER performance curves when a spreading factor $N=4$ has been used with a two antenna receiver.

DETAILED DESCRIPTION OF THE INVENTION:

As stated above, in a synchronous CDMA downlink using orthogonal codes, multiple access interference (MAI) is essentially caused by the multipath channel. Therefore, MAI may be suppressed by linear channel equalization. A receiver using a channel equalizer algorithm is disclosed, which performs linear interchip interference cancellation by adaptive chip separation. The method is suitable for systems with long code scrambling, such as the proposed third generation wideband CDMA systems. The results are shown below to provide considerable performance gains when compared to a conventional RAKE receiver.

In an aspect of this invention, a CDMA terminal space-time adaptive receiver structure is disclosed for the downlink of CDMA systems employing long code scrambling. The receiver's ability to suppress MAI is based on equalizing the effects of the multipath channel, which essentially restores the orthogonality between different users. The adaptation rule is derived from the bootstrap principle, and its applicability here stems from the observation that the downlink signal is a sequence of uncorrelated, fairly high-powered signal elements, i.e. multiuser chips. An objective of the adaptive separation is to remove the correlation between the chips caused by the channel. Thus, the receiver performs linear channel equalization by adaptively decorrelating consecutively transmitted chips. The approach has particular application to the CDMA downlink, since the signal sent by the synchronous base station transmitter is formed by a sequence of uncorrelated multiuser chips, and it has a suitable signal-to-noise ratio for this application. Thus, the power of the entire multiple access signal can be utilized for adaptation.

I.   DOWNLINK SIGNAL MODEL

A.   TRANSMITTED SIGNAL

In a CDMA downlink, the different users' signals are symbol synchronous, and distinguished from each other with orthogonal (Walsh) codes. The typical structure of a single base station transmitter with K simultaneous users is depicted in Figure 1. Signals $b_1, ..., b_K$ are the complex quadraphase shift keying (QPSK) data symbols for each of 1 through K users. The Walsh code for each user is represented by $s_1(n)$, $s_K(n)$ applied at junctions 100, through 100. User dependent power control

resulting signals are combined by the summation function 120. A common complex scrambling code c(n) is applied to the combined signals at junction 130. The resulting signal is shown as d(n).

The overall multiuser chip sequence is:

$$d(n) = \sum_i \sum_{k=1}^{K} a_k b_k(i) s_k(n - iN)c(n) \, ,$$ (1)

where, for the kth user, a_k is the real positive amplitude due to power control, $b_k(i)$ is the ith complex QPSK data symbol, and s_k is the Walsh code. Here, for $n = 0, 1,$ ..., N-1, $s_k(n) = \pm 1$, and 0 elsewhere. The period of the common complex scrambling code $c(n)$ may extend over an entire frame of symbols. Due to the long PN code scrambling, $\{d(n)\}_n$ is a sequence of uncorrelated complex signal elements, and due to the user-dependent power control, its amplitude distribution is unknown to the receiver. However, from the adaptation point of view, $d(n)$ represents the signal to be estimated.

The chips are given a transmission waveform $p(t)$ of limited bandwidth. Thus the continuous time model for the multiple access baseband signal is:

$$u(t) = \sum_n d(n)p(t - nT_C) \, ,$$ (2)

where T_C is the chip interval duration.

B.   RECEIVED SIGNAL

Due to multipath propagation, the received chip waveform at the mth receiver antenna is:

$$h_m(t) = \sum_{l=1}^{L} \gamma_{ml} p(t - \tau_l) \, ,$$ (3)

where γ_{ml} is the complex gain, and τ_l is the relative delay of the lth path of the multipath channel. Since, compared to the chip rate, the channel parameters are slowly time-varying, they may well be assumed constant over the time interval of interest. Thus the received signal at the mth antenna is:

$$r_m(t) = \sum_n d(n)h_m(t - nT_C) + \eta_m(t) \,, \qquad (4)$$

where $\eta_m(t)$ is a process of white Gaussian background noise (AWGN) with two-sided power spectral density $N_0/2$. For a matrix representation, the continuous time waveform $h_m(t-nT_C)$ may be discretized into a vector $\mathbf{h}_m(n)$. The infinite, M-dimensional received signal may be stacked into a vector

$$\mathbf{r} = \begin{bmatrix} \mathbf{r}_1 \\ \mathbf{r}_2 \\ \vdots \\ \mathbf{r}_M \end{bmatrix}, \qquad (5)$$

which is given by the matrix equation

$$\mathbf{r} = \mathbf{Hd} + \boldsymbol{\eta} \,, \qquad (6)$$

where the vector $\mathbf{d}$ includes the transmitted multiuser chips

$$\mathbf{d} = \begin{bmatrix} \cdots & d(-1) & d(0) & d(1) & \cdots \end{bmatrix}^T, \qquad (7)$$

and the matrix $\mathbf{H}$ includes the received waveforms

$$\mathbf{H} = \begin{bmatrix} \cdots & \mathbf{h}(-1) & \mathbf{h}(0) & \mathbf{h}(1) & \cdots \end{bmatrix}, \qquad (8)$$

so that each of the column vectors of matrix $\mathbf{H}$, for $n = \ldots, -1, 0, 1, \ldots,$

$$\mathbf{h}(n) = \begin{bmatrix} \mathbf{h}_1(n) \\ \mathbf{h}_2(n) \\ \vdots \\ \mathbf{h}_M(n) \end{bmatrix}, \qquad (9)$$

represents the received waveform conveying the information of the transmitted multiuser chip $d(n)$.

II.   ADAPTIVE RECEIVER

A.   OVERALL RECEIVER STRUCTURE

A block diagram of the structure of the receiver 10 is depicted in Figure 2. Signals $r_1(t)$ through $r_M(t)$ are received through at least one or a plurality of antennas 140_1, ..., 140_M which are each coupled to a corresponding chip matched filter 150_1, ..., 150_M. Each chip matched filter 150_1, ..., 150_M produces at least one sample per chip at its output. The chip sample sequences pass through delays 160_1, ..., 160_M to compensate for possible channel estimation delay.

In order to determine the mutually correlated chip estimates, the coherent RAKE receiver 170 includes a unit, designated Chip MRC 175, for performing chip maximal ratio combining (MRC) over multipath components and antenna elements. The operation corresponds to channel matched filtering, and as such, minimizes the signal dimensionality with no loss of information prior to equalization.

Reference in this regard may be had to: I. Kaya, A. R. Nix and R. Benjamin, "Exploiting multipath activity using low complexity equalisation techniques for high speed wireless LANs," *IEEE International Vehicular Technology Conference*, VTC'98, Ottawa, Canada, May 1998, pp. 1593-1597.

The mutually correlated chip estimates are adaptively separated by the adaptive separation filter 180. The output of the adaptive separation filter 180 is coupled to a correlator 190 which operates to obtain estimates for the desired users' data symbols by despreading the signal, i.e. by multiplying with a conjugated long scrambling code and user specific Walsh code, supplied by a code generator 200, and then integrating over the symbol period. The output of the correlator 190 is coupled to a deinterleaver 210 which in turn is coupled to a decoder 220. The deinterleaver 210 and the decoder 220 could be conventional in construction and operation.

Assuming perfect knowledge of the channel, the nth output element of the Chip MRC 175 is:

$$x(n) = \mathbf{h}^H(n)\mathbf{r} = \sum_{m=1}^{M}\sum_{l=1}^{L} \gamma_{ml}^* \int r_m(t)p(t - nT_c - \tau_l)dt , \qquad (10)$$

where $(\ )^*$ denotes taking complex conjugate and $(\ )^H$ Hermitian transpose. In matrix form, the total output sequence $x = [\ \ldots, x(-1), x(0), x(1), \ldots\ ]^T$ is

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$$\mathbf{x} = \mathbf{H}^{H}\mathbf{r} = \mathbf{Pd} + \mathbf{H}^{H}\mathbf{\eta},\tag{11}$$

where the correlation matrix $\mathbf{P} = \mathbf{H}^{H}\mathbf{H}$ is denoted.

In practice, instead of known γ_{ml}, coherent combining employs estimates $\hat{a}_{m,l} \cong \gamma_{ml}$ for $m = 1, \ldots, M$ and $l = 1, \ldots, L$ of the channel response provided by amplitude estimators $230_1, \ldots, 230_L$. These estimations may be based on dedicated pilot symbols or on a common pilot channel, received through antennas $140_1, \ldots, 140_M$.

From equation (11), it can readily be seen that by multiplying the vector x from the left with $\mathbf{P}^{-1}$, chip decorrelation or zero-forcing equalization is performed. However, such an operation offers little advantage due to considerable noise enhancement.

B. ADAPTIVE SEPARATION

Due to multipath propagation, the combined chips are mutually correlated. The objective of the adaptive separation filter 180 is to remove this correlation. Since the correlation matrix $\mathbf{P}$ is of Toeplitz form, the separation is reduced into a filtering problem. As depicted in Figure 3, a symmetric filter v is used. Ideally, the filter is infinitely long, but in practice it may be truncated into a manageable length. A suitable filter length may be determined primarily by the channel delay spread. By denoting:

$$\mathbf{x}(n) = \begin{bmatrix} x(n-F) \\ \vdots \\ x(n-1) \\ x(n) \\ x(n+1) \\ \vdots \\ x(n+F) \end{bmatrix}, \text{ and } \mathbf{v}(n) = \begin{bmatrix} v_{F}(n) \\ \vdots \\ v_{1}(n) \\ 1 \\ v_{1}^{*}(n) \\ \vdots \\ v_{F}^{*}(n) \end{bmatrix},$$

where $2F+1$ is the filter length, the output of the separation filter 180 may be expressed as

$$z(n) = \mathbf{v}^{H}(n)\mathbf{x}(n).\tag{12}$$

Similarly to the above mentioned bootstrap algorithm described by Y. Bar-Ness and J. B. Punt, the adaptation is based on blind linear decorrelation. The adaptation step of the weights, for $f = 1, 2, \ldots, F$, may be expressed as:

$$v_f(n+1) = v_f(n) - \mu(n)z^*(n)z(n-f) \ , \tag{13}$$

where $\mu(n)$ is the (possibly normalized) step-size parameter. Note that in the initial condition, $v_f = 0$, for $f = 1,2, ..., F$, the overall receiver acts as a conventional RAKE receiver.

From equation (13) it can be shown that when the adaptation has reached the steady state (in the mean), the condition

$$E\big(z^*(n)z(n-f)\big) = 0 \ , \quad f = 1, 2, ..., F \tag{14}$$

is satisfied. When the noise level is insignificant, this condition is also satisfied by a zero-forcing equalizer.

It should be noted that the steady-state filter weights cannot be solved from equation (14) without ambiguity, and that the algorithm does not offer global convergence. However, simulations have shown that the adaptation is stable if the step-size is kept reasonably small.

III. PERFORMANCE EVALUATION

In this section, the results of the computer simulations determining the bit error rate (BER) performance of the adaptive chip separator, are presented, and compared to those of a conventional RAKE receiver. Consider a WCDMA downlink signal with K active, equal power users, QPSK data modulation and real orthogonal Walsh codes of length $N = 4$ or 32, along with a long complex Gold sequence for scrambling. A fixed step-size parameter is used for adaptation, and the separation filter length is set to 17 ($F = 8$). Error correction coding is excluded from the simulations.

The receivers are tested in a time-varying Rayleigh channel with delay spread 1 μs, with three resolvable paths of equal average powers, each independently fading according to a classical Doppler spectrum. A chip rate of 4 MHz with root raised cosine pulse shape filtering, a carrier frequency of 2 GHz, and a vehicle speed of 5 km/h are used in the simulations. Both single-antenna, and two-antenna receivers are simulated. In the two-antenna case, full diversity due to independent fading between the elements is assumed. Perfect estimates of the channel impulse response are given to the receivers.

In Figure 4, the BER performance curves of single antenna receivers in the case of spreading factor N=32, with variable number of users, are depicted. The performance of the two-antenna receivers in the corresponding channel load situations are shown in Figure 5. Here, the x-axis indicates the E_b/N_0 per antenna
5   element. The results for the single- and two-antenna receivers in the low spreading factor N=4 situation are given in Figures 6 and 7, correspondingly.

As can be seen, the chip separator offers considerable gain compared to RAKE especially in heavily loaded channels. The separator also seems to benefit more from the extra dimension given by the diversity antenna. In the single user case of
10   low data rate and large spreading factor N=32, however, the detection performance is just slightly decreased due to adaptation jitter. It is worth noting though, that a high data rate user with N=4, clearly benefits from the separation even in the single user case.

The simulations show that the adaptive chip separator outperforms the conventional
15   RAKE receiver, especially at high data rates when the spreading factor is small, or when the system is heavily loaded by multiple users.

It should be understood that the functions described herein may be implemented with discrete circuit elements, or as software routines that are executed by a suitable data processor. A combination of circuit elements and software routines may also be
20   employed.

Thus, while the invention has been particularly shown and described with respect to preferred embodiments thereof, it will be understood by those skilled in the art that changes in form and details may be made therein without departing from the scope and spirit of the invention.

CLAIMS

What is claimed is:

1.   A receiver for use in a CDMA telecommunications system, comprising:

5   at least one antenna for receiving signals from a CDMA channel, said signals comprising a desired user signal;

combining circuitry, coupled to said antenna, for performing chip waveform filtering and maximal ratio combining over multipath components and antenna elements to produce mutually correlated chip estimates of said received signals;

10   an adaptive separator, coupled to said combining circuitry, for adaptively separating said mutually correlated chip estimates; and

a correlator, coupled to said adaptive separator, for despreading an output of said adaptive separator to obtain an estimate for data symbols of said desired user signal.

15   2.   The receiver of claim 1, further comprising estimating circuitry, coupled to said combining circuitry, for estimating a response of said channel, and wherein said combining circuitry utilizes said channel response estimate as a reference.

3.   The receiver of claim 1, wherein said despreader further comprises circuitry for multiplying said output of said adaptive separator with a conjugated long 20   scrambling code and a Walsh code, and then to integrate the result over a symbol period.

4.   A method for receiving signals in a CDMA telecommunications system, said method comprising the steps of:

receiving signals from a CDMA channel, said signals comprising a desired 25   user signal;

performing chip waveform filtering and maximal ratio combining over multipath components and antenna elements to produce mutually correlated chip estimates of said received signals;

despreading said separated mutually correlated chip estimates to obtain an estimate for data symbols of said desired user signal.

5. The method of claim 4, further comprising the step of estimating a response of said channel, and wherein said step of performing chip waveform filtering and maximal ratio combining further comprises utilizing said channel response estimate as a reference.

6. The method of claim 4 wherein said step of despreading further comprises the steps of multiplying said adaptively separated mutually correlated chip estimates with a conjugated long scrambling code and a Walsh code, and then integrating the result over a symbol period.

7. A coherent RAKE receiver for use with received CDMA waveforms comprising a desired user signal, said receiver comprising:

combining circuitry, responsive to said received CDMA waveforms, for performing chip waveform filtering and maximal ratio combining over multipath components and antenna elements to produce mutually correlated chip estimates of said received CDMA waveforms;

an adaptive separator, coupled to said combining circuitry, for adaptively separating said mutually correlated chip estimates; and

a correlator, coupled to said adaptive separator, for despreading an output of said adaptive separator to obtain an estimate for data symbols of said desired user signal.
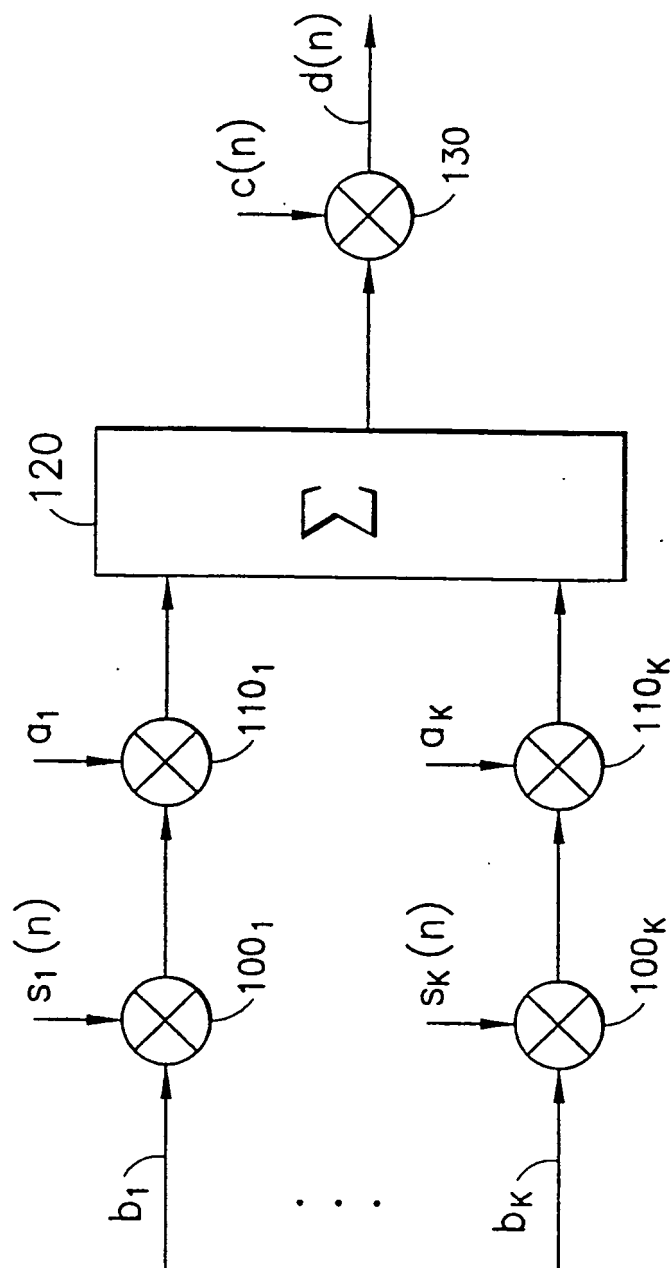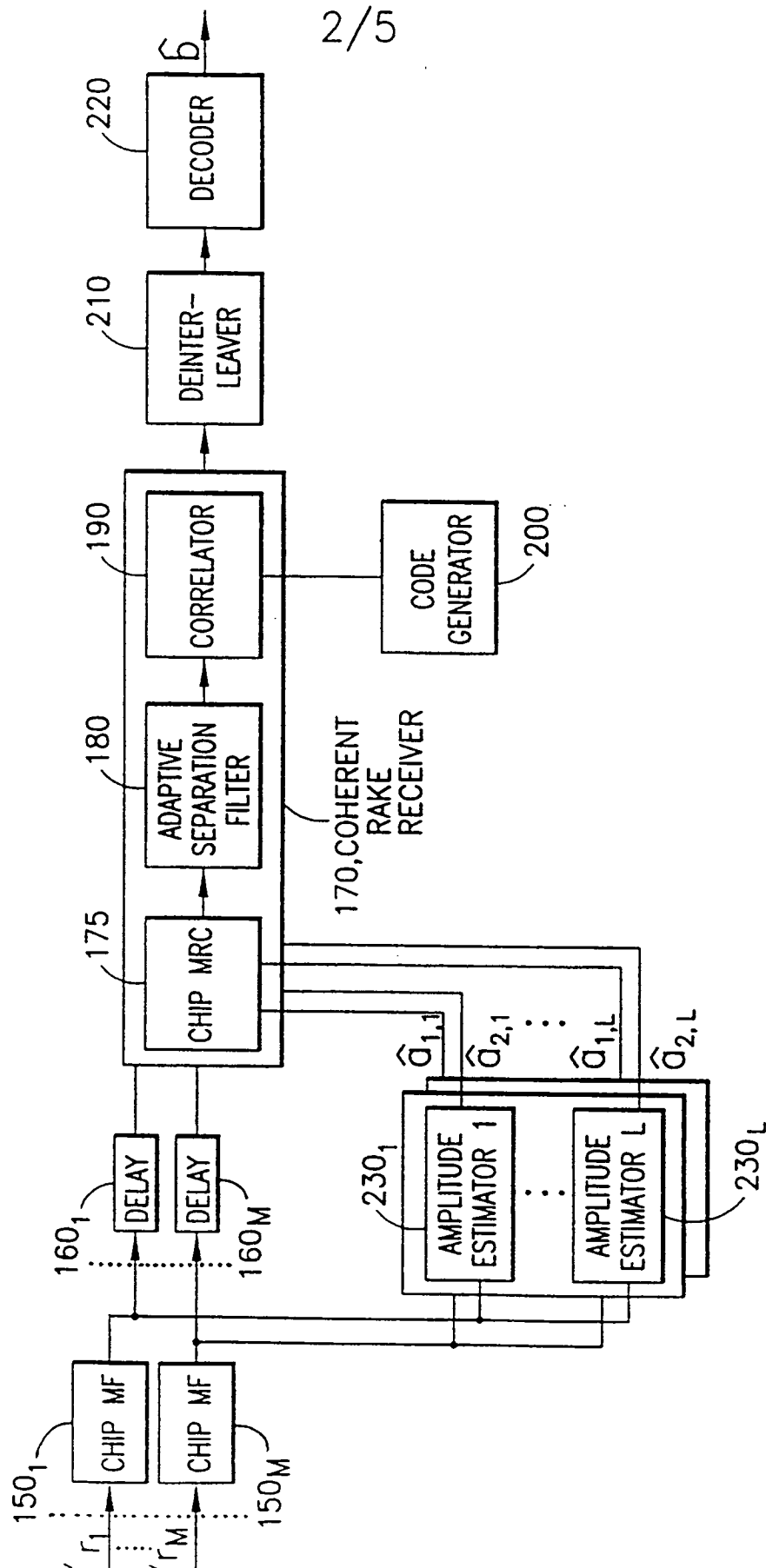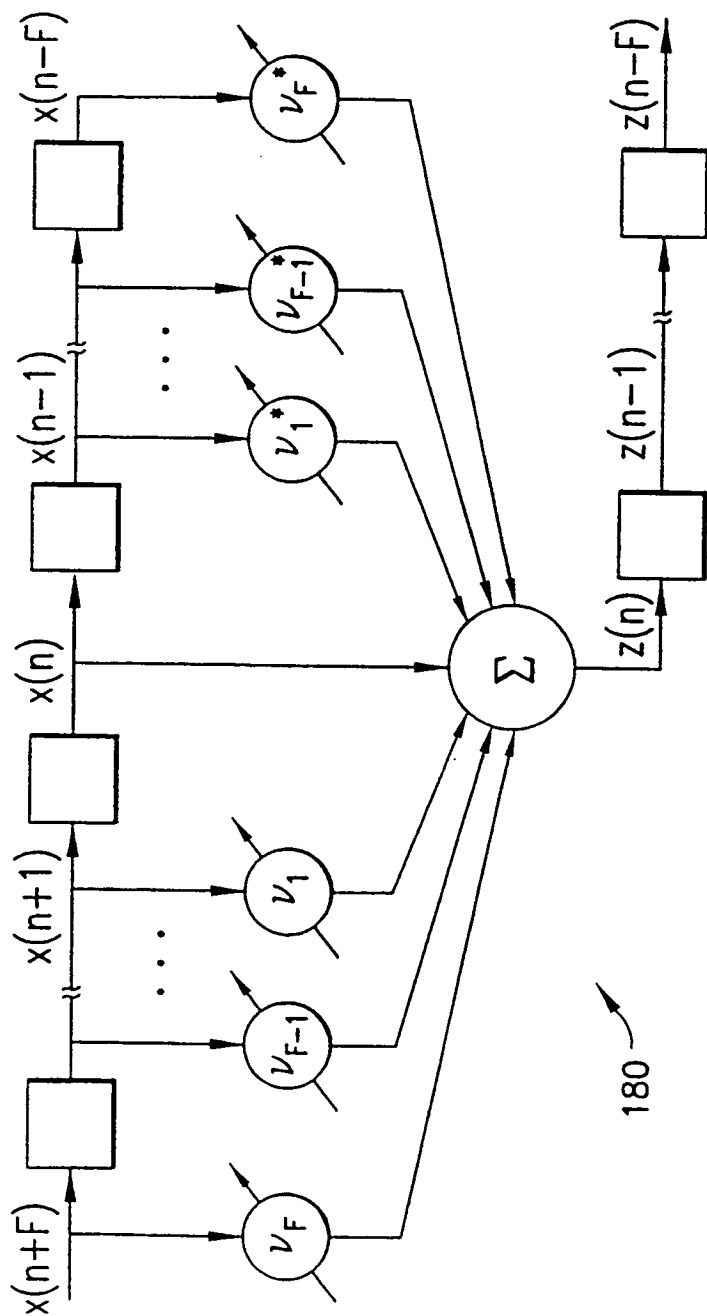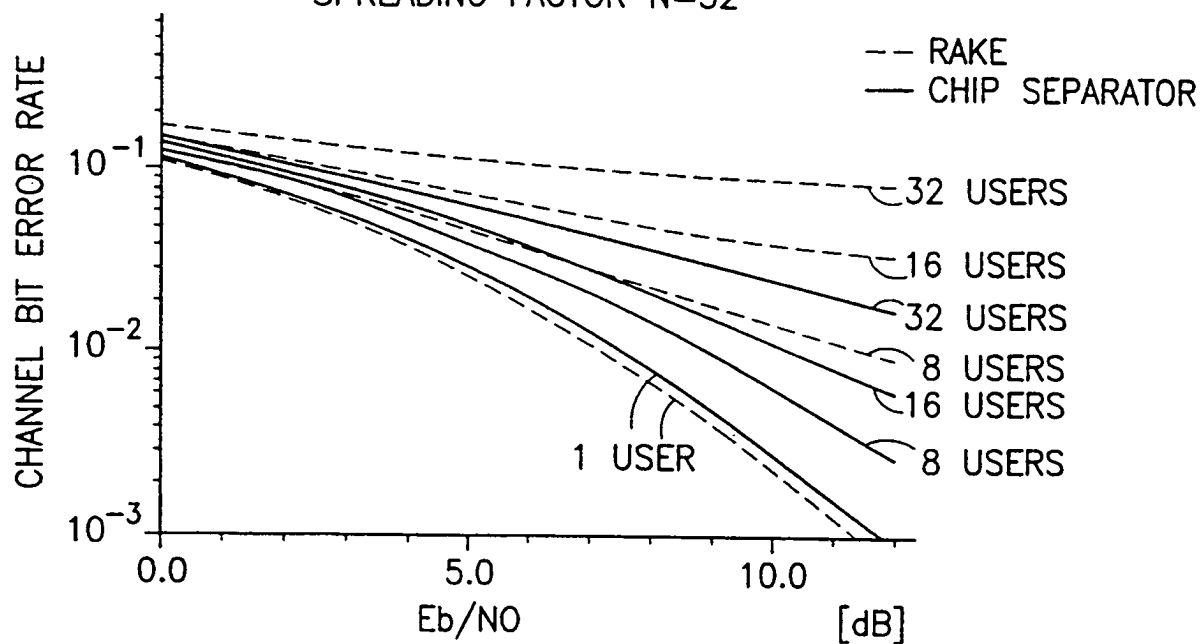
FIG.1

FIG.2

FIG.3

SPREADING FACTOR N=32

FIG.4

SPREADING FACTOR N=32, ANTENNA DIVERSITY
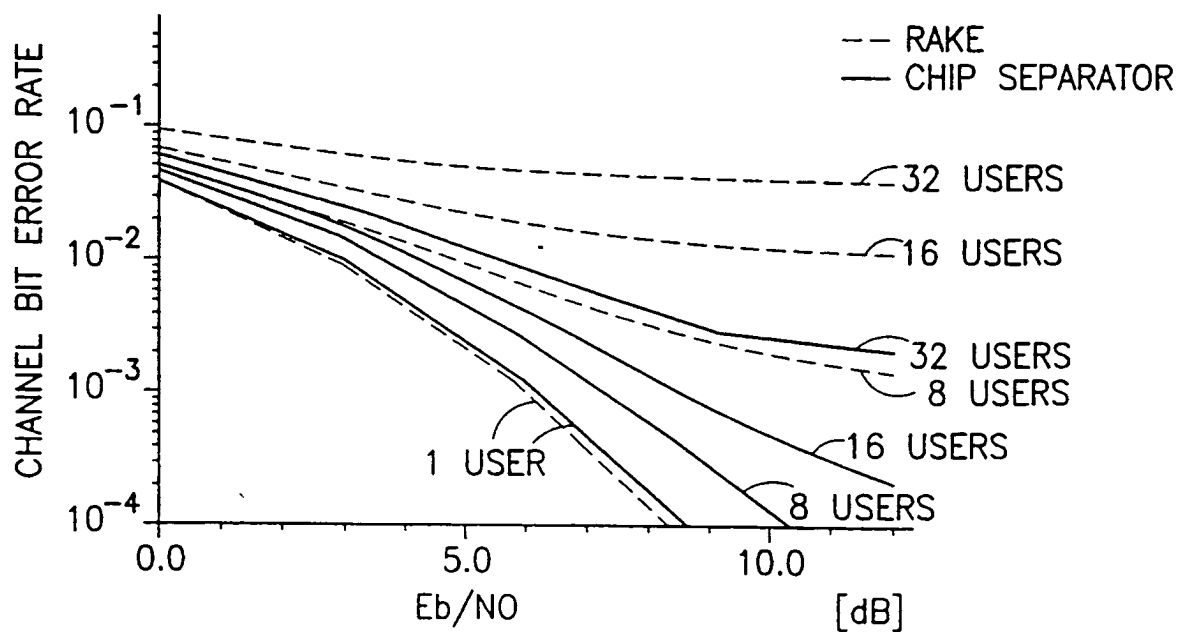
FIG.5

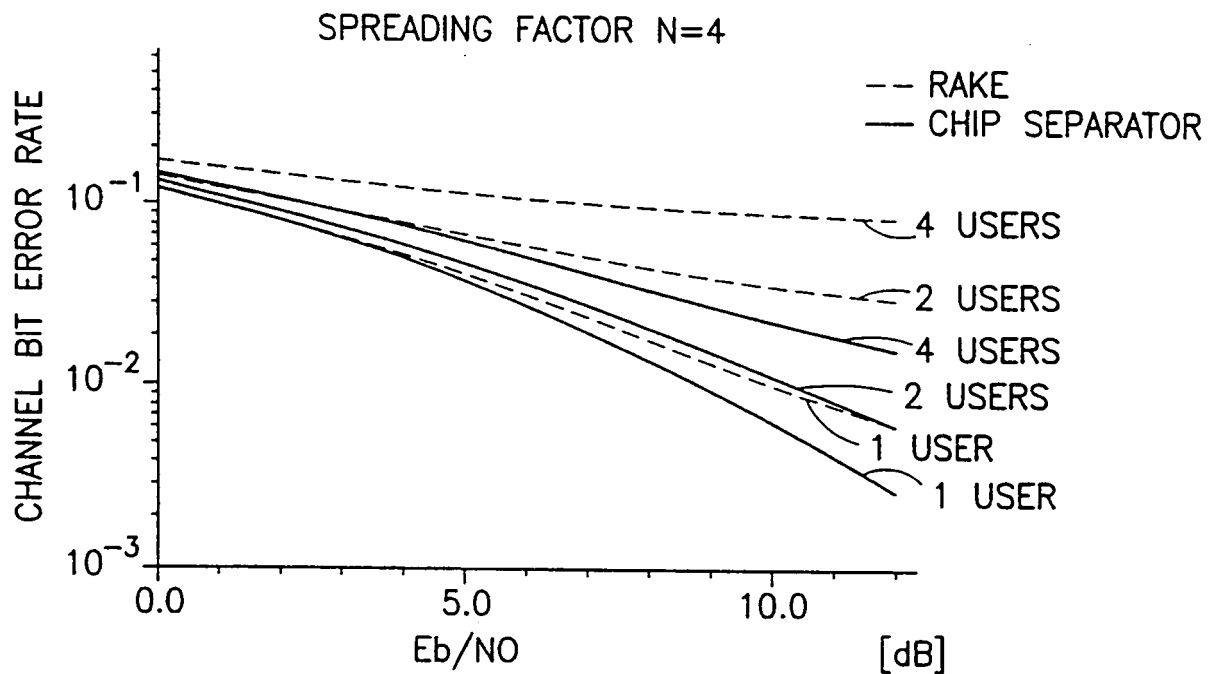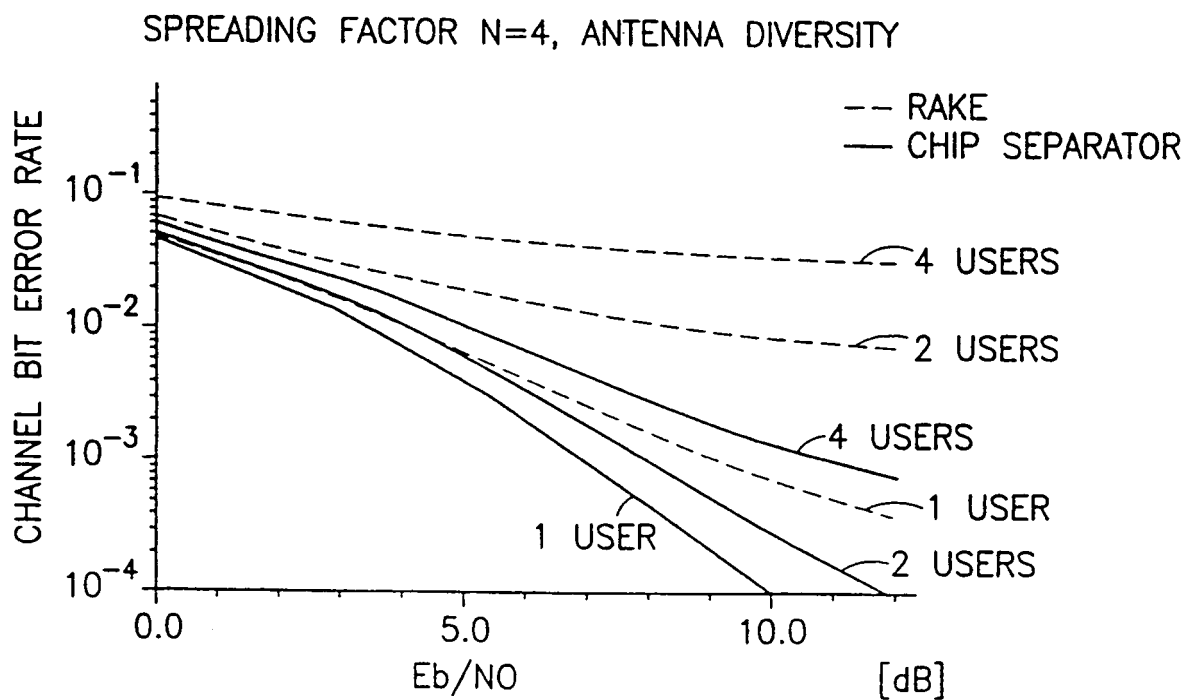SPREADING FACTOR N=4

FIG.6

SPREADING FACTOR N=4, ANTENNA DIVERSITY

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INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04B 1/06
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04B, H04J, H04K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0631399 A1 (TSUJIMOTO, ICHIRO C/O NEC CORPORATION), 28 December 1994 (28.12.94), page 9, line 24 - line 29, abstract	1,4,7
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A	US 5577025 A (GORDON SKINNER ET AL), 19 November 1996 (19.11.96), abstract	1,4,7
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☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance		
"E"	erlier document but published on or after the international filing date	"X"	document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
"O"	document referring to an oral disclosure, use, exhibition or other means	"Y"	document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 August 2000	**08 -08- 2000**

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				AU	6635696	A	05/02/97
				CA	2202621	A	23/01/97
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